NETWORK

FIELD OF THE INVENTION

This invention relates to diversity in wireless networks, and in particular to implementations of
5   macro and micro diversity at a distributed access point in a wireless LAN. The network may
implement a range of wireless protocols such as IEEE 802.11a and 802.11b for terminals
communicating through the access point.

BACKGROUND TO THE INVENTION

10 Wireless LANs (local area networks) are emerging as important infrastructure for a wide range
of commercial and domestic premises. They enable mobility of wireless devices about the
premises and are generally more flexible and lower cost than networks with equivalent wired
connections. However, a large number of wireless access points may be required to properly
serve the coverage volume of a particular network, and different mobile devices may require
15 service within the volume using different wireless protocols. This increases the number of
wireless interface controllers with RF (radio frequency) transceivers that are required by the
network, and therefore increases its cost. Distributed access points having a number of relatively
simple cells or POPs (points of presence) for transmission and reception of RF signals are
therefore under development. Each access point has a central server with a set of transceivers
20 that are typically connected to the POPs by optical fibres, coaxial cables or the like, through a
bridge or switch.

Diversity techniques can improve wireless communication by selecting one channel, or
combining a subset of channels, from a range of decorrelated channels that may exist between a
transmitter and a receiver. A range of different algorithms exist for selecting or combining
25 signals from among the available channels. In spatial diversity each channel is a physical path
between a transmitting antenna and a receiving antenna, with selection of the most suitable
receiving antenna according to analysis of the respective signal. Macro diversity counters large
scale and generally static spatial variations between the receiving antennae such as shadowing.
Micro diversity counters relatively small scale and often time varying effects such as multipath

fading. Both macro and micro spatial effects can be important in wireless LANs with distributed access points.

SUMMARY OF THE INVENTION

5   It is therefore an object of the invention to provide for the use of spatial diversity techniques in wireless LANs having distributed access points, or at least to provide an alternative to existing diversity systems in wireless networks.

In one aspect the invention may broadly be said to consist in a communications network comprising: two or more cell sites for communication with wireless terminals, at least one of the

10   cell sites having multiple receive antennas; and a central site having one or more interface controllers and a switch system through which the controllers are connected to the cell sites; wherein for each controller in communication with a wireless terminal, a cell site is selected for reception of signals from the terminal, and for each selected cell site having more than one receive antenna, an antenna within the site is selected for reception from the terminal.

15   Preferably the network further comprises: a cell selector in the central site that uses a diversity technique to select cell sites for reception from the wireless terminals and connects the selected sites to respective controllers through the switch. Preferably the network further comprises: an antenna selector in each controller that uses a diversity technique to select an antenna within each cell site having multiple receive antennas. Preferably the interface controllers include

20   transceivers that transmit and receive RF signals according to respective protocols that are used by the wireless terminals, and preferably the central site is connected to at least some of the cell sites via optical fibres.

The invention may also be said to consist in any alternative combination of features that are suggested in this specification of the drawings. All equivalents of these features are deemed to

25   be included whether or not explicitly set out.

LIST OF FIGURES

Preferred embodiments of the invention will be described with respect to the accompanying figures, of which:

30   Figure 1 shows a prior art wireless network with a distributed access point,

Figure 2 shows how macro diversity may be implemented in a distributed access point,

Figure 3 shows how micro diversity may be implemented in a distributed access point,

Figure 4 shows how both macro and micro diversity may be implemented in a distributed access point,

5   Figure 5 shows how macro and micro diversity may be alternatively implemented in a distributed access point, and

Figure 6 gives detail of the macro diversity selection in Figure 5.

DESCRIPTION OF PREFERRED EMBODIMENTS

10   Referring to the drawings it will be appreciated that the invention can be implemented in a range of wireless networks in a range of different ways. The embodiments described here are given by way of example only.

Figure 1 schematically shows part of a network serving a number of wireless terminals WT1-4 through a distributed access point. The access point includes a server 10 connected to a wired

15   network 11 and to a number of points of presence POP1-3, being three in this example, each having RF transmit and receive antennas. Each POP represents a small cell site for radio communication. The server contains one or more controllers, commonly called NICs (network interface cards) that carry out various functions including conversion of signals between protocols and carriers used on the wired and wireless parts of the network. The controllers are

20   connected to the POPs through a switch 12 that enables any one of the NICs to transmit and receive RF or IF signals through any one of the POPs. Each POP has a connection 13 to the switch, by way of optical fibre in this example, with RF signals being modulated and demodulated onto and from optical signals at each end of a fibre. A series of ports are provided for each of the POPs respectively in an opto-electronic module 14. Connections may also be

25   made by a range of other means such as coaxial cable. The wireless terminals WT1-4 may communicate with each other, and with fixed terminals 15 or other wireless and fixed terminals in the network through the access point.

Figure 2 schematically indicates how macro diversity techniques may be implemented among POPs at the distributed access point in Figure 1. Server 10 includes two interface controllers

30   NIC1-2, provided as cards, that enable communication with devices using any of a range of

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wireless protocols such as IEEE 802.11a and 802.11b, for example. The two NICs, a processor 20, memory 21 and network port 22 in the server are connected by address, data and control buses, shown in simple form for clarity. Processor 20 carries out a range of general functions for the access point, including frequency planning, power control, diagnostics and network

5   management via SNMP (simple network management protocol) for example. Switch 12 preferably includes separate transmit and receive switching components 23 and 24 respectively, to reduce cross talk when transferring transmit and receive signals between the NICs and the POPs. Both switch components are set by a controller 25. Switch connections have been shown in simple form for NIC1 only. Opto-electronic module 14 includes a series of ports 26 for fibre

10   optic connection to the POPs, each having an optical transmitter and an optical receiver, typically lasers L1-3 and photodiodes P1-3 respectively. Outputs from the transmit switching component 23 are connected to the lasers L1-3.

Macro diversity in Figure 2 is implemented by way of a selection system 27 connected between the opto-electronic module 14 and the receive switching component 24 of the switch 12.

15   Outputs from the photodiodes P1-3 are connected to inputs of the receive switching component 24, with portions of the signals being passed through filters F1-3 respectively in the selection system. Output from each of the filters is connected to a detector 28. The signal received from a POP may contain individual signals representing separate communications on several channels in several bands. For example, a POP that is constructed to enable IEEE 802.11a and b will

20   potentially receive signals on several channels in each of the 5.2GHz and 2.4GHz bands that have been defined for those standards. The filters F1-3 are therefore preferably narrow-band per-channel filters and the detector 28 preferably has a separate power detector for each possible channel for each POP. Power or signal levels are preferably detected near the channel centres only, or pattern matched across multiple channels, to improve rejection of power from

25   neighbouring channels. Various known diversity algorithms can be implemented by the selection system 27 for analysis of the signals from each POP, such as signal power, channel delay spread, channel matrix eigenvalue spread and preamble soft error magnitude. Output from the selection system 27 is used by the switch controller 25 to set pathways through the receive switching component, so that each NIC in the server 10 receives an optimum signal from a

30   selected POP.

Figure 3 schematically indicates how micro diversity techniques may be implemented in POPs at the distributed access point in Figure 1. Many of the elements in this figure are the same or

similar to those of Figure 2. Switch connections have been shown in simple form for NIC2 only.
Each POP now has more than one receive antenna and is able to provide two or more versions of
the same signal to the server 10 through the switch 12. In this example, each POP has two
receive antennas that provide signals to the opto-electronic module 14 along separate optical

5   fibres. Each port 26 in the module 14 now includes an optical transmitter such as a laser L1-3,
and two optical receivers such as a photodiode P1-3 and P1'-3'. Separate receive switching
components 30, 31 are preferably provided in the switch 12, corresponding to the number of
signals from each POP. The transmit and receive switching components are set by the controller
25. A diversity selection system 33 in each of the interface controllers NIC1-2 selects from the

10   received signals from a particular POP. Both of the received signals from a particular POP are
delivered to a particular NIC by the switch controller generally according to macro diversity
techniques that may also be implemented. Various known diversity algorithms can be
implemented by the selection systems 33 for analysis of the signals from each POP as mentioned
above.

15   Figure 4 shows schematically how a distributed access point combining both macro and micro
diversity techniques may be implemented. Many of the elements common to the preceding
figures have been omitted, while some extra detail has been included, and only a single NIC 40
has been shown. In this example, there are eight POPs 41 each with a transmit antenna 42 and
two receive antennas 43, 44 enabling selection from eight channels for macro diversity and two

20   channels for micro diversity. Each antenna may operate in multiple bands, covering both of the
bands prescribed for IEEE 802.11 a and b, for example. Each POP is connected by optical
fibres to an opto-electronic port 26 having a laser L for optical transmission and two photodiodes
P, P' for optical reception. In this example, the outgoing signal to each POP shares an optical
fibre 45 with one of the incoming signals from the POP, while a separate fibre 46 is provided for

25   the other incoming signal. The POPs may also contain lasers, photodiodes, amplifiers, filters,
frequency converters and optical multiplexers as required. The NIC carries out both macro and
micro diversity selection, with all of the signals received from all of the POPs capable of being
presented to the selection system 47. Some specific components of the NIC including an I/O
port for connection to the server, a MAC processor for analysing packets received from wired or

30   wireless terminals, a baseband modem for conversion of digital signals to and from quadrature
form, and an RF or IF stage for modulation and demodulation of the quadrature signals onto high

frequency carriers are also shown. Specific transmit and receive connections are also shown in the switch, again by way of example.

Figure 5 shows an alternative implementation of macro and micro diversity in a distributed access point. Many of the elements common to the preceding figures have been omitted for

5   simplicity, while some extra detail has been included. In this example there are again eight POPs each with two receive antennas, enabling macro and micro diversity selections from eight and two channels respectively. Four NICs 50 have now been shown with specific receive switching connections 51, and opto-electronic ports 52. Only a few of the total number of receive connections in the switch have been shown, while the transmit connections have been omitted

10   altogether. The two receive switch components preferred for transfer of signals from each pair of receive antennas in the POPs are shown in overlay form. Macro diversity selection is carried out on the POP side of the switch by filters and power detectors in block 27 as in Figure 2, with adjustment of the switch being carried out by control 25. Micro diversity selection is carried out by the NICs as in Figure 3. Alternatively, both macro and micro diversity selection may be

15   carried out on the POP side of the switch.

Figure 6 gives some detail of the diversity selection system 27 in Figures 2 and 5. A pair of signals is input to the selection system from a POP having two receive antennas. The signals are received along an optical fibre by an O/E card 60 containing suitable opto-electronic components, typically photodiodes. Each signal from an antenna may contain component signals

20   from a range of wireless terminals using a range of different protocols. In this case, the signals are broadly filtered 61 according to two prescribed bands, such as the 2.4GHz and 5.1GHz bands of the IEEE 802.11 standards. A portion of the signal in each band is then filtered by a respective bank of narrow band filters 62 covering each of the available channels. The power in each channel is determined and output as data to a local processor 63, generally part of the

25   switch control 25. A control signal from the main processor 20 in the access server 10 in Figure 2 is also usually received. Output from the local processor is used to determine the switch settings 51 in Figure 5. The pair of signals are then passed through buffers 64.

Diversity arrangements implemented according to the invention are able to achieve selection and switching on practical time scales. The selection process should generally take place as close as

30   possible to the switching mechanism to reduce any delay in operating the switch. It is preferred that selection by macro diversity take place prior to switching and that selection by micro

diversity take place after the switch. However, it will be appreciated that various combinations of diversity selection and switching will be appropriate in different networks.